Plant Ecology, Examination 2, November 9, 2000 Name _____

Please restrict your response to the space available. Answer directly and fully - don't beat around the bush. The point values for each question are given in parentheses. Your notes added to the Winston's PDF printout may be helpful in answering the exam. All page references refer to Winston Weatherby's notebook. Question #7 is a bonus.

1 (15). Most people would find it odd that the photosynthetic data on page 106 indicate that CO_2 is evolved from leaves of *A. caudatus* in the dark (PFD = 0), but not from leaves of *A. cruentus*? What strikes you as odd about this difference between the two curves at the lowest PFD levels? Could it be that Winston incorrectly plotted one of these data sets?

What is odd is that the A. cruentus leaves appear not to have any respiration in the dark (PFD = 0). This is odd and in fact cannot be correct. In the dark, all eaves respire (mitochondrial respiration). Either the data for A. cruentus are incorrectly plotted or incorrectly collected.

2 (12). OK, let's stay on page 106. Full sunlight has a PFD value of about 2.0 mmol m^{-2} s^{-1}. Assuming that leaves of the two amaranth species have similar leaf absorptance characteristics, is it unusual or to be expected that the slope of the relationship between net photosynthesis and incident PFD (over the range 0-1 mmol m^{-2} s^{-1}) is approximately the same between the two species? Explain your answer.

The slope of the photosynthesis versus light response curves should be similar between the two species at low PFD values. The slope of the line in this PFD region is linear and reflects the quantum yield (mol CO_2 fixed per mol photons). Since both of the plants are C_4 plants, we expect their quantum yields to be similar.

3 (15). On page 107, why is the relationship between net photosynthesis by amaranth leaves and leaf nitrogen content linear? Explain your answer.

The nitrogen concentration of leaves reflects protein concentrations within leaves. Since more than half of the protein in a leaf is associated with photosynthesis, the increase in protein content reflects an increase in leaf photosynthetic capacity. The linear relationship between photosynthesis and leaf nitrogen reflects the observation that under most conditions, the overall rate of photosynthesis is limited by nitrogen content.

4 (12). What we now know is that there were some wispy trees shading parts of the field when Wanda collected the data on page 109. Provide the correct mechanistic explanation for why the internodal distance between successive leaves is responding to the red-to-far-red ratio within the amaranth canopy.

Internodal distance between successive leaves is responding to the red-to-far-red ratio within the amaranth canopy, reflecting the activity of phytochrome as a sensor

controlling leaf elongation. Phytochrome is a pigment responding to the red-to-far-red ratio. Depending on the ratio of ed-to-far-red light, phytochrome promotes different elongation rates as a mechanism to extend leaves of amaranth from shade to sunnier light environments.

5 (15). Regarding the data on page 110, provide a simple mechanistic explanation for why the growth of a plant (measured in g m^{-2}) should be positively correlated with carbon isotope discrimination. Justify your answer. Remember that this is "carbon isotope discrimination" and **not** "carbon isotope ratio".

The positive relationship between carbon isotope discrimination and growth is consistent with stomatal conductance limiting photosynthesis. These data suggests that increases in intercellular CO_2 concentrations result in increased growth. We know that discrimination is positively related with intercellular CO_2 concentration and that photosynthetic rate is also positively related to intercellular CO_2 concentration. One simple way to increase photosynthesis and thereby growth is to increase stomatal conductance.

6 (16). OK, please help Winston with his data on page 111. Please fill in the correct carbon isotope ratios for these samples. Remember the values are -29.1, -25.8, -16.2, and -15.9 per mil. From page 112 of Winston's notebook (which you did not have access to earlier), we now know that the carbon isotope ratio values are only different from each other if the values differ by more than 0.3 per mil.

amaranth leaf, well watered	**-16.2 or -15.9 per mil**
amaranth leaf, limited water	**-16.2 or -15.9 per mil**
wheat leaf, well watered	**-29.1 per mil**
wheat leaf, limited water	**-25.8 per mil**

7 (15). OK, let's think about the data on page 108. It turns out that all of these data were collected from the same leaf, simply by changing the incident PFD levels and observing the response. Using an Ohm's Law analogy, what was the intercellular CO_2 within the leaf when the leaf conductance was 300 mmol m^{-2} s^{-1}? [Show your calculations.]

If you assume that the leaf conductance is the conductance to CO_2, then

$A = (ca - ci)g$ ----> $ci = ca - A/g$ ---> $260 = 350 - 30 \cdot 1000/300$

If you assume that the leaf conductance is the conductance to H_2O, then

$A = (ca - ci)g/1.6$ ----> $ci = ca - A/g$ ---> $206 = 350 - 1.6 \cdot 30 \cdot 1000/300$

The factor of 1000 is to convert from micro to milli, so that A and g units have a common unit basis.

8 (15). OK, a bit more about the data on page 108. What does a linear relationship between net photosynthesis and leaf conductance say about the values of intercellular CO_2 over the leaf conductance range of 50 - 350 mmol m^{-2} s^{-1}? Specifically, over the leaf conductance range of 50 - 350 mmol m^{-2} s^{-1}, is the intercellular CO_2 value constant, increasing, and/or decreasing? Justify your answer.

The linear relationship between photosynthesis and leaf conductance indicates a constant intercellular CO_2 concentration. Specifically, as shown above,

$A = (ca - ci)g/1.6$ ----> $ci = ca - A/g$

Therefore, if the data in the figure on page 108 all fall along a single line, the A/g is constant and the ci value is also a constant.